



Office of the Secretary of Defense  
Defense Microelectronics Activity  
(DMEA)



***RoHS/Pb-free  
electronics for DoD?  
Managing the Pb-free  
electronics transition***



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# Outline



- Background
- Risks and Impacts
- Pb-free Guidance Efforts
- PERM
- Pb-free Electronics Risk Reduction Project
- DoD Technology Focus Team
- Summary



# Background

## *There is a global transition to Lead-free*

- **Reduction of Hazardous Substances (RoHS)**
  - EU Directive banning “placing on market” new electronic equipment containing specific levels of the following after July 1, 2006
    - **Lead**, Cadmium, Mercury, hexavalent chromium, polybrominated biphenyl (PBB), polybrominated diphenyl ether (PBDE) flame retardants
- **Waste Electrical and Electronic Equipment Directive (WEEE)**
  - EU directive aims to minimize the impact of electronic waste
  - Encourages and sets criteria for collection, treatment, recycling
  - Makes the *producer responsible*
- Related/updated legislation in place or underway in China, Japan, Korea, California, EU, and others

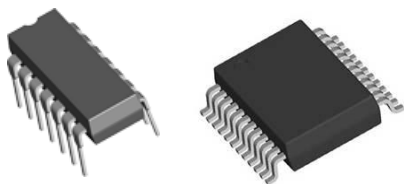
*Lead-free brings new and re-emerging failure modes in electronics*



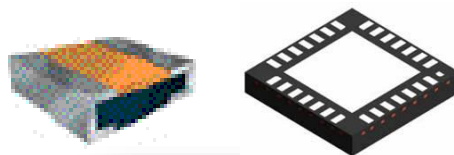


# How Products are Affected

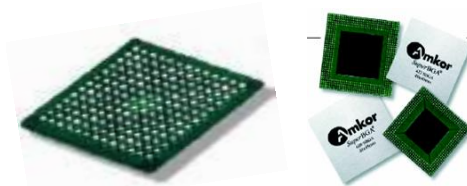
Leadframe Finish



Leadless Termination Finish



BGA Solder Balls

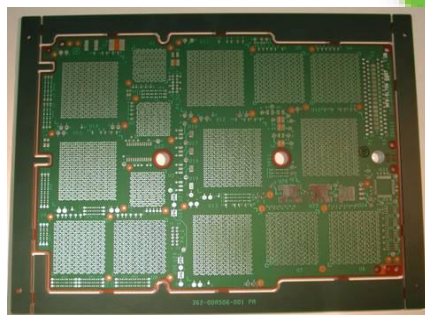


Common Lead-free finishes on current products: matte tin, NiPdAu, SnAgCu

COMPONENT FINISHES

PWB FINISHES

SOLDER



Today: Tin-Lead HASL  
Tin-Lead plate and fused



Wave



Paste

Today: SnPb solders



Wire

Also mechanical parts: connectors, lugs, cardguides, packages, lids, etc.



# Why are Lead-Free Electronics a challenge ?



- DoD (and Aerospace/High Performance) systems have unique requirements:
  - High reliability and critical systems
  - Very long service life
  - Extreme operating environments
  - Repairable systems
- Pb-free alloys present a completely new material set
  - Vastly different metallurgical properties
  - Little test and qualification data
  - Material set is still changing

DoD acquisition programs are increasingly dependent on *commercial* electronic parts and assemblies (COTS)





# Pb-free Electronics Risks



## ➤ “Tin Whisker” Short Circuits

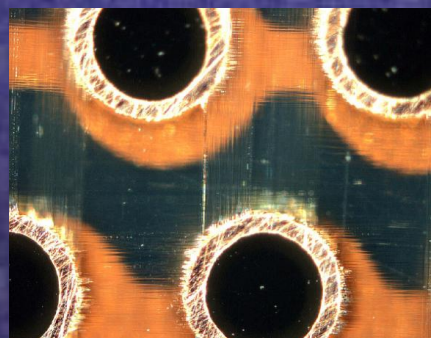
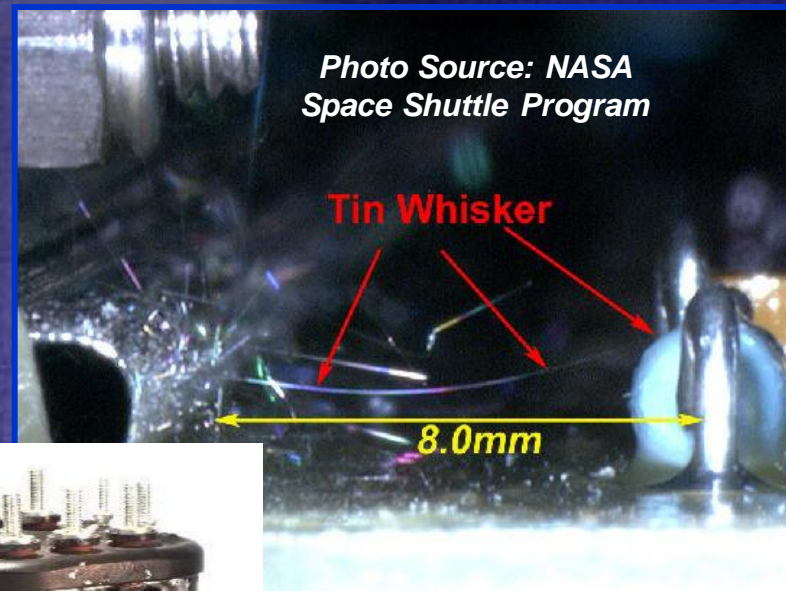
- Electrically conductive
- Can metal vapor arc

## ➤ Pb-free Solder Issues

- Fractures in high shock & vibration environments
- Has higher melting temps
- Incompatibilities with SnPb Solder
- Conductive Anodic Filament (CAF) problem is re-emerging
- Less repairable assemblies

## ➤ Configuration Control

- Unidentified component alloys
- Mixed Pb & Pb-free inventory







# Pb-free Electronics Technical Impact on Defense & Aerospace



- No universally acceptable technical solutions in sight to replace SnPb in defense applications
  - Conformal coatings only mitigate tin whiskers
  - Pb-free solder joint reliability decreased for shock
  - SAC305 solder dissolves copper, impacting rework and repair
  - Conductive Anodic Filament (CAF) problem is re-emerging due to higher CCA processing temperatures using Pb-free solders
- Current technical approaches are all still “mitigations” and not “elimination” of the Pb-free electronics issues





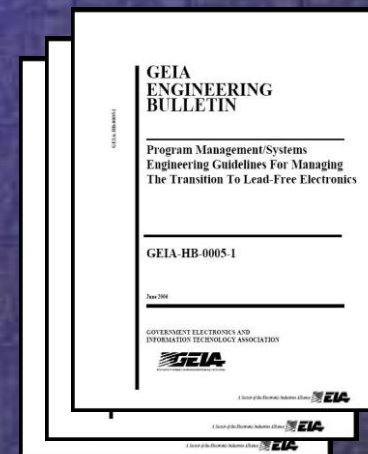
# Pb-free Guidance Efforts

- AIA-AMC-GEIA Lead-free Electronics in Aerospace Project Working Group (LEAP WG) 2004-2009
- Executive Lead-Free Integrated Process Team (ELF IPT) 2004-2009
- LSA, STWG, LFET
- Aerospace industry research
- JG-PP, NASA/DoD, CALCE
- Produced 7 Standards and Handbooks
  - **GEIA-STD-0005-1** Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder
  - Available from TechAmerica

AIA = Aerospace Industries Association

GEIA = Government Electronics & Information Technology Association

AMC = Avionics Maintenance Conference



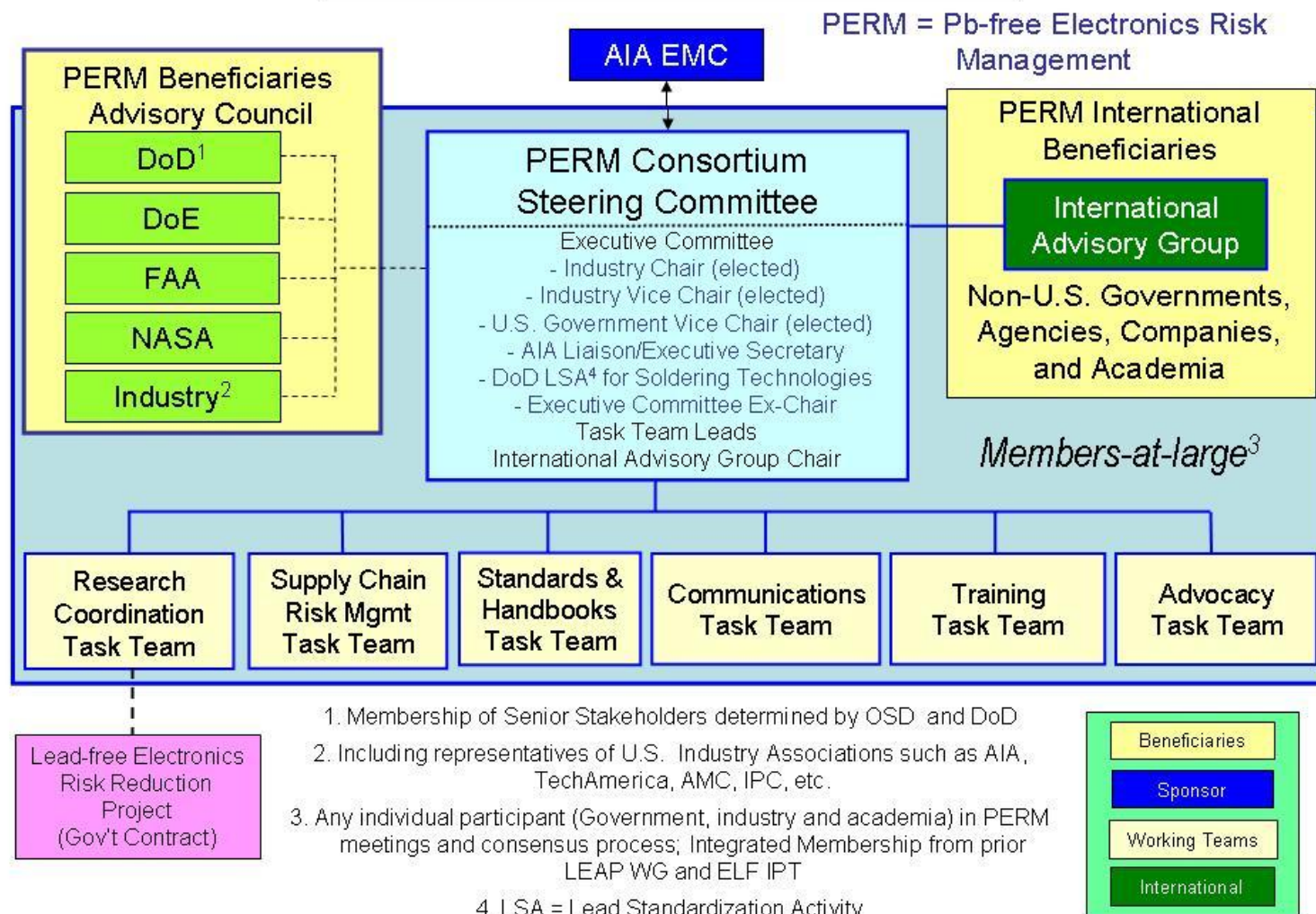




# Pb-free Electronics Risk Management PERM Consortium



## PERM Consortium Functional Framework







# Pb-free Electronics Risk Reduction Project Concept



- **Who:**
  - 17 recognized deep subject matter experts assembled to work as a single, fully-funded team
  - Strong team leader with requisite management and technical skills
  - Government Funding Champion at highest possible level
- **What:** “Find acceptable replacements for Pb in electronics for use in aerospace and defense environments” (Dual Use)
- **When:** Begin ASAP with a 3-year commitment and hope for shorter
- **Where:** National Lab or Research Center
- **How:** \$105M Dedicated “Pocket change funding” compared to the scope of the problem
- **Why:** Given time, the “Business Case” will become self-evident based on events, even to the most strident “nay sayers”



# Pb-free Electronics Risk Reduction Project

**“Manhattan” Project**

**Pb-free Electronics Risk Reduction Project**

*ONR Funded*

**Phase 1: Best Practice Baseline**

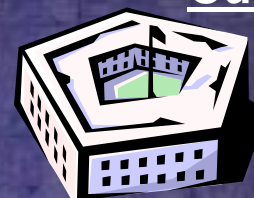
*JDMTP Funded*

**Phase 2: Technology Roadmap**

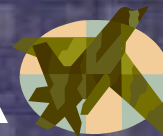
**Phase 3 – Integrated Risk Reduction Projects**

- Tin Whiskers
- Electronics Assembly
- Solder Joints
- Electronic Component
- Printed Circuit Boards

Customers



*DoD plus...*



**2009**

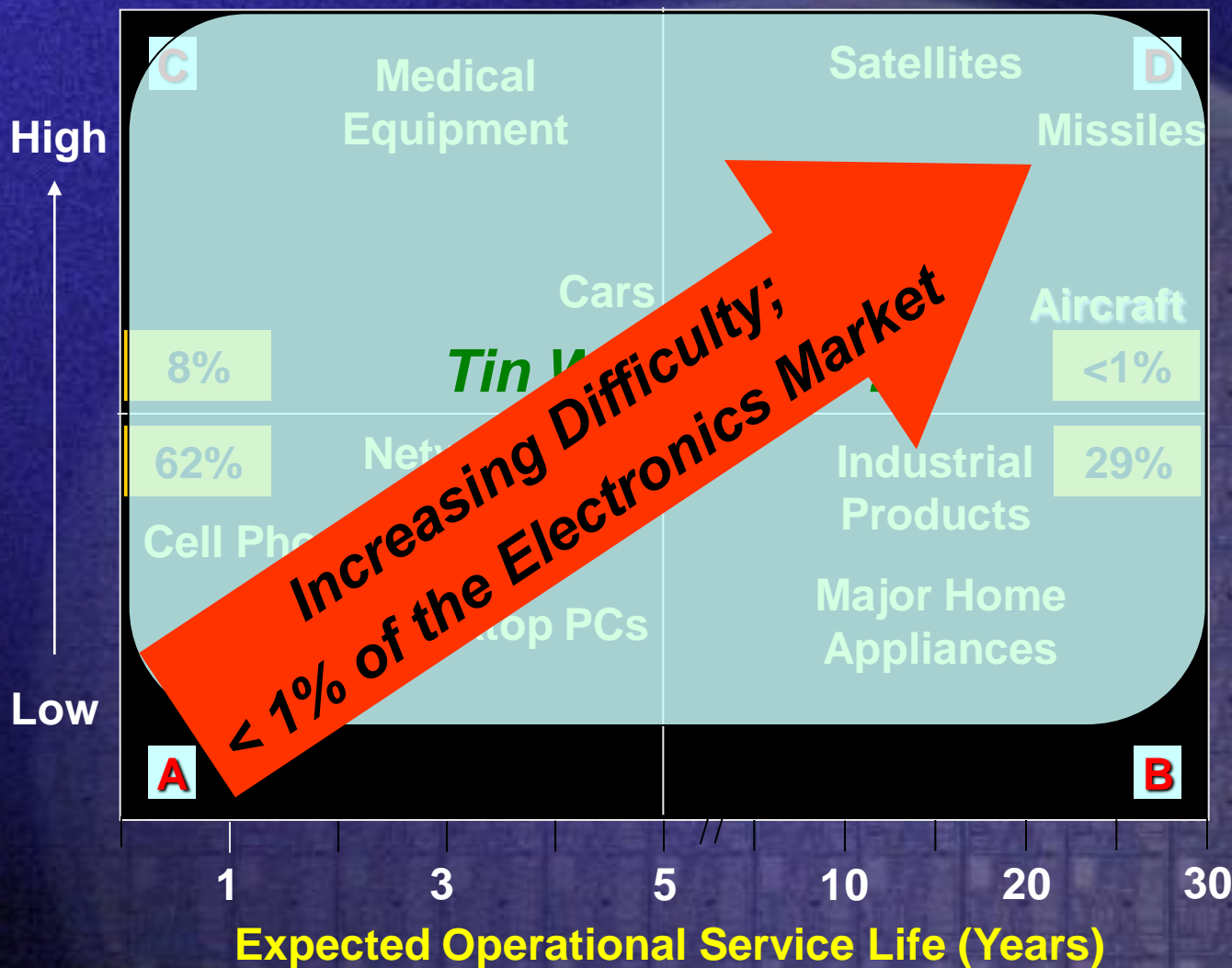
**2010-2013----**





# Pb-free Electronics Operating Environment vs. Operational Life-time

**Consequences of Failure**  
**Harshness of Service Environment**  
(Humidity, Temperature, Shock, Vibration)





# DoD Lead-free Electronics Technology Focus Team



- Directed by Defense Research & Engineering
- Chartered to engage all stakeholders in Government and industry
- Advise DDR&E
  - Defense industrial base
  - Policy
  - Technology gaps
  - Standards
  - R&D investments





# Summary

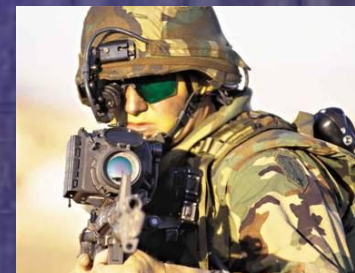
## DoD Response to Lead-Free



- There is a global transition to lead-free
  - Lead-free solder issues
  - Tin whisker risks
  - Availability of leaded solder and components
  - New repair processes
  - Configuration control challenges
- Programs must assess risks and manage the transition
- Challenges
  - Pb-free policy at DoD, Service and Program levels
  - Guidance and awareness
  - R&D investments - \$\$\$



*The DoD must **continue** to field reliable and supportable systems to meet mission requirements*





# Questions



Tin Whisker Photo courtesy of  
Peter Bush, SUNY at Buffalo

